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Design Criteria Information System (DCIS)

Recommendations for Enhancement of the Design Criteria Information System (DCIS)

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Architectural and Engineering Instructions (AEIs) comprise a large, complex body of mandatory design criteria and guidance for U.S. Army Corps of Engineers (USACE) facility designers, engineers, and contractors. The unabridged set of AEIs, which fills more than 1500 pages, is often out of date because AEIs are revised much more frequently than updates are published. Furthermore, to hold down printing and distribution costs, the unabridged body of AEIs receives very narrow distribution. Consequently, hard copies of the latest AEIs have been difficult for the end user to obtain on a timely basis.

The Design Criteria Information System (DCIS) was developed to make current AEIs accessible worldwide to any authorized user with a microcomputer and a modem. DCIS, which resides on the Corps' Programming, Administration, and Execution (PAX) mainframe system, has solved the fundamental problem of distributing current AEIs online. However, DCIS cannot distribute drawings or graphics online, its text-retrieval functions are limited, and the mainframe's supporting technology makes the system cumbersome to use.

This report surveys technologies that could be exploited to enhance DCIS, outlines three general alternatives for enhancement, and assesses the advantages and disadvantages of each. Development of a minicomputer-based system employing CD-ROM (compact disc - read only memory) technology, and accessible via microcomputer and telecommunications, is recommended.

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FOREWORD

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RECOMMENDATIONS FOR ENHANCEMENT OF THE DESIGN CRITERIA INFORMATION SYSTEM (DCIS)

1 INTRODUCTION

Background

To help control facility construction costs and quality for military construction projects, Headquarters, U.S. Army Corps of Engineers (HQUSACE) publishes Architectural and Engineering Instructions (AEIs)—a category of design criteria and guidance for Corps of Engineers districts and the architect/engineer (A/E) firms that work for the Corps on contract. AEIs direct the designer to current published guidance published by the Corps and the Department of Defense (DOD), but they also contain specific design criteria. In addition to being a resource for the designer, AEIs are used in the planning, programming and management of Corps construction projects.

AEIs comprise a complex set of information that has traditionally been published and distributed as paper documents. The unabridged set of AEIs covers criteria for 12 specific types of facilities, and includes regional criteria variations that do not apply to all locations worldwide. This document, which fills more than 1500 printed pages, is published periodically by the Government Printing Office and other printing services. In an effort to control the cost of printing and handling of this unwieldy body of information, AEIs are given relatively narrow distribution. This method of dissemination has proven unacceptable because (1) printed AEIs were never distributed directly to the end user even though the end user is required to follow this guidance, and (2) individual AEIs are revised much more frequently than the complete set of them is reprinted. In other words, these mandatory design criteria have been difficult for the end user to obtain, and frequently have been out of date when they *were* obtained (Flickinger and Solon-Wetmore 1991).

To address these problems, HQUSACE developed a plan for making AEIs available on a computer network. The U.S. Army Construction Engineering Research Laboratory (USACERL) was tasked to develop and implement the plan. The product of this work was the Design Criteria Information System (DCIS), an automated system that provides (1) up-to-date versions of AEIs to authorized Army Engineer users and contractors, (2) an online library of related reference material for end users, and (3) procedures that give criteria maintainers ready access for updating AEI text while keeping the updating process within control of the system administrator (Flickinger and Solon-Wetmore 1991).

The capabilities provided by DCIS have proven beneficial to users, but several problems and limitations are inherent in the way the system was implemented. DCIS is available to users over modem on the Corps' Programming, Administration, and Execution (PAX) mainframe system. Limitations imposed by the mainframe system's supporting software and hardware make information access cumbersome for the user. Also, current system technology prevents DCIS from incorporating graphics, which are often an important part of design criteria. This means the user must still obtain printed documentation for access to the complete content of updated AEIs. Furthermore, the use of DCIS on PAX can lead to high costs for connect time and online processing.

A number of existing and emerging technologies (e.g., expert systems, hypermedia) have the potential to effectively address the problems described above. Appropriate technological solutions offer substantial potential benefits for Corps users and contractors.

Objective

The objective of this research was to (1) investigate commercial software products that may address the shortcomings of DCIS as currently implemented and (2) recommend a general strategy for the most effective implementation of a DCIS system upgrade.

Approach

A summary of DCIS enhancement issues was prepared. A survey of applicable software technologies was then conducted, with attention to the hardware requirements and operating system compatibilities of each. Three general platform-specific alternatives for enhancing DCIS were presented. Finally, one of these three alternatives was recommended as the most desirable strategy for enhancing the capabilities of DCIS.

Scope

Enhancement of DCIS will require a complete rewrite of the source code to support hypermedia applications. Although the general costs of each DCIS enhancement alternative were considered wherever they were obvious and substantial, this study was not intended to document or analyze the specific costs of incorporating hypermedia capabilities into DCIS. The focus was on the technology of the potential alternatives.

2 INVESTIGATION OF TECHNOLOGIES FOR ENHANCEMENT OF DCIS

Enhancement Issues for DCIS

Although DCIS was originally conceived as a tool for the timely distribution of AEI revisions to the end user (Flickinger and Solon-Wetmore 1991), it is evident that hypermedia technology could greatly enhance the system's effectiveness.

The term *hypermedia* refers to computer technology that gives the user access to a wide variety of information media, including text, graphics, voice (sound), and motion video. Although these information formats have been usable on computers for a considerable time, hypermedia programs offer an important new advantage: access to separate media from within a single application. The user can access, process, and integrate different information formats without exiting his or her current application. Data for various media are available via image processing and storage equipment (e.g., video cameras, digitizing scanners, compact disc - read only memory [CD-ROM]). These data may be stored on conventional magnetic disks, retrieved into random access memory (RAM), and transmitted through telecommunications channels or networks.

Incorporating hypermedia into DCIS is desirable for several reasons. Under DCIS as currently implemented, references made within AEI documentation must be located by exiting the AEI and navigating a series of menus. The user cannot even know whether the reference is available online without interrupting his or her work in DCIS. This can waste much time and contribute to higher costs for connect time. Perhaps a more serious shortcoming is the system's inability to present AEI drawings or graphics online. This weakness can substantially negate the advantages of distributing AEIs online; the user must obtain hard copies of AEI illustrations independently of DCIS. Considering the nature of facility design criteria in general, it is evident that an online source of such information is incomplete without the ability to access graphics.

Under the current source code for DCIS, users cannot even efficiently access data that *are* stored within the system. After conducting a study of DCIS users for the system's sponsor under a separate contract, the software developers recommended that DCIS source code be completely rewritten and data be restructured for an expert system or hypermedia application (William Flickinger, trip report for Chief, USACERL-FS, 31 July 1991).

Investigation of currently available hypermedia applications focused on programs that offer (1) the ability to access graphics files and (2) hypertext capabilities. As stated previously, online access to graphics would represent a substantial advance over the current capabilities of DCIS. Furthermore, hypertext functions would highly refine the ways in which users may query the information base and sort data retrieved from it. This *text retrieval* capability would allow users to scan AEI text on the basis of very narrow specifications. It would improve the efficiency of the search by finding data in a shorter time. Additionally, it would only provide data requested by the user, not the bulk of unwanted text retrieved through the less refined search capabilities of the current system. Refined text retrieval functions would spare the user the tedium and wasted time of weeding through masses of unwanted information on the way to finding a specific item.

A literature search was conducted to survey the "state of the market" in the area of text and graphics retrieval. The intent was to broaden knowledge on the capabilities of these emerging technologies and understand how the commercial software developers and markets have been approaching them.

Survey of Mainframe-Resident Programs

BRS/SEARCH

The Corps currently licenses the text retrieval program BRS/SEARCH for use by the HQUSACE staff. Consideration of this package included a demonstration for the authors by company personnel, and examination of in-depth information about the software.

BRS Software Products has been involved in optical disc technology since 1982. One of the foundation CD-ROM packages produced by BRS is BRS/SEARCH, an information retrieval package available for both microcomputers and minicomputers. It uses standard boolean, relational, and special proximity operators. The program includes online user help and usage statistics. Its operation includes word root and prefix searching, nested search logic, saved search strategies, back-referencing of queries, full pattern matching (truncation), and paragraph (field) qualification. Similarities to the DCIS program code include queued offline printing, sorting printed output, redirected printed output, online message transmission, and intelligent function keys. A notable feature is its ability to compress database files.

Special features of BRS/SEARCH include an extensive data security system that can be applied at the user, database, and system levels. Several convenient display, browsing, and printing features are available also, including user-defined formats for report generation. Database records can be added, modified, or deleted online, and the package also offers menu-driven interfaces. A companion module, BRS/MAINT, guides users through design and maintenance of BRS/SEARCH databases, and automatically loads the databases. Graphics capabilities for the system are currently under development. Costs were not discussed when the system was demonstrated.

Other than providing a mechanism to search for a word or phrase, BRS/SEARCH does not offer any new capabilities to DCIS. The search function is format-specific, and would not be user-friendly to an inexperienced user. For example, suppose a first query produces 239 documents and a second query produces 299. To find documents based on both queries 1 and 2, the system seeks keywords from both queries occurring in the same paragraph. The command for this third query would be typed "1 same 2." This is the standard kind of logic a programmer would use, but not the way a typical DCIS user would intuitively respond.

Because DCIS is written to operate in the PAX environment, using BRS/SEARCH with DCIS under VM/CMS* (the PAX operating system) requires the following: VM/CMS version 3.22 or later, Lattice C Runtime Library version 3.00F (supplied with the package), a virtual machine with at least 1.5 megabytes (MB) of hard storage space, and a minimum of 5 MB of virtual machine storage for loading databases. Minidisk requirements for the minimum storage space are 300 kilobytes (kB) for minidisk A, 8 MB for minidisk J, and 2 MB for minidisk L. The PAX environment meets all of these requirements.

BASISplus

BASISplus is a new generation document management system for retrieval, manipulation, and storage of full text, graphics, image, and alphanumeric data. It provides a repository for revisable form/compound document access and interchange, and true-form presentation of information from many types of data files and systems, including ASCII/EBCDIC,** word processing and electronic publishing systems, optical character recognition (OCR) scanners, graphics packages, and bitmapped images, among

* VM/CMS: Virtual Machine/Conversational Monitor System.

** ASCII/EBCDIC: American Standard Code for Information Interchange/Extended Binary-Coded Decimal Interchange Code.

others. BASISplus also includes content-based retrieval features, intelligent search assistance, and a variety of user interfaces, including native environment and graphical user interfaces.

BASISplus features open architecture for building applications, supports relational and client/server models for distributed processing, and complies with industry standards for document interchange and access. It can run on anything from workstations to mainframes, and can support small or very large applications. It is compatible with a variety of operating systems, including VM/CMS. With BASISplus, documents can be secured with both read and write protection. BASISplus also offers both online and batch options for search instruction input. When a document is changed, BASISplus automatically places the new version of the document in the database, and immediately makes necessary changes to the index file. It can monitor when changes were made, and by whom.

This package requires 2 MB of disk storage and a minimum of 512 kB of RAM and supports code written in Assembler, FORTRAN, or C. Maintenance and technical support are provided free for the first 6 months, after which support can be extended for 1 percent of the current license fees for all components in the configuration. Prices range from \$5000 to \$179,000.

DOCU/MASTER

DOCU/MASTER is an online, interactive document management system that can retrieve text documents through searches based on specific words, phrases, or concepts. It accesses structured, database-oriented information as well as unstructured, text-oriented documents. DOCU/MASTER uses an indexing algorithm that minimizes storage requirements and facilitates automatic indexing of every word and number. DOCU/MASTER includes three interfaces: a menu-driven interface for novice users, a command-oriented interface for more experienced users, and an application program interface that allows its content-search capabilities to be included in other applications. There are no specific predefined field or document structure requirements. DOCU/MASTER accepts a full 80-character line length as input.

User access to databases can be limited to "read only," "read and update," or "no access permitted." Its search capabilities include word proximity, range searching, and wildcard characters. Documents may be updated in both batch and online modes. The index file for updated documents is only modified with the batch update run. There is a basic set of commands for minor document changes such as add/delete/replace documents, lines within a document, or characters within a line. There is also a full screen editor for more complex document changes.

DOCU/MASTER requires a minimum of 320 kB of RAM and an IBM or plug-compatible mainframe with System/370 architecture (e.g., IBM 30xx, 43xx, 93xx series; Amdahl, Canon, etc.). It is compatible with VM/CMS and other operating systems. Perpetual site licenses range from \$37,500 to \$84,500, including source code. Term lease plans are also available. The purchase price includes 12 months of free maintenance. After that, optional annual maintenance is available at 15 percent of the purchase price.

TextView

TextView capabilities are designed to accommodate diverse information management needs within the IBM mainframe environment. It specializes in large volumes of online updates and requests, allowing many users to access both structured and unstructured data simultaneously. Files may be edited online. TextView uses a proprietary inverted-index structure that allows its index to be only 35 percent of the data portion. The system can base searches on any of the following methods: full boolean, wildcard, table of contents, thesaurus, phrase, phonetic, proximity, or hyperlink.

The central repository enables document storage, control, and access functions to meet security needs. Nine levels of security are available to control which users and which terminals can view, update, or copy documents. The program also supports user profiling, making it possible to limit a user's view of information based on identification (ID) access. It comes with complete application-development resources.

Prices range from about \$10,000 to \$60,000. TextView requires a minimum of 200 kB of RAM, and is compatible with VM/CMS and most IBM operating systems. Maintenance costs 16 percent of the current license fee per year after the first year.

INQUIRE/Text

INQUIRE/Text is a text retrieval system developed by Info Systems, Inc., for IBM-compatible mainframes. Its search methodologies include positional inverted, nonpositional inverted, and free text scan. It provides a user interface for full-screen *ad hoc* text searches. INQUIRE/Workstation is a new PC client product for accessing a text database on a mainframe. Release E also contains SQL Bridge, which allows the user to embed structured query language (SQL) statements in INQUIRE applications, or enter them from the terminal. INQUIRE/Text interfaces directly with a DOS-based product called Folio VIEWS, which allows the user to view the contents of text files without opening them. (Folio VIEWS is discussed under "Information Retrieval Software for Microcomputers and Minicomputers.")

This package requires a minimum of 1 MB of RAM. Its source languages include ALC and PL/1, and it is compatible with VM/CMS. Pricing starts at \$99,000. Site licenses are available, and maintenance is available for a yearly fee of 14 percent of the purchase price.

Status/IQ

Status/IQ stores and retrieves text and unstructured information. It offers word and phrase search capabilities on databases containing free text and numeric information. The system permits full online update of both text and the index. It runs with the same functionality on mainframes, minicomputers, and microcomputers.

An inverted index is used to support a retrieval system that interfaces with 35 different word processing packages, provides hooks to image-handling software, and accepts instructions in real time (as opposed to batched). It performs Boolean searches and offers a plain-English interface for users inexperienced in data processing. In addition, Status/IQ offers an advanced ranking facility that ranks the retrieved list on various inputs, including automatically assigned term weights, directing the user to the most pertinent references. This program also includes a range of security capabilities. Only users authorized to do so can see or change information. Also, specified parts of records can be made secure from general access.

Status/IQ requires at least 1 MB of RAM and 5 MB of disk storage. It is compatible with DOS,* VM/CMS, and several other operating systems. FORTRAN and C are the source languages. Pricing depends on hardware configurations, ranging from \$25,000 to \$130,000. Lease plans and site licenses are also available. Maintenance is available for \$500 to \$1600 a month, and telephone support is free for the first 90 days.

* DOS: disk operating system, the widely used operating system for IBM-compatible microcomputers.

Information Retrieval Software for Microcomputers and Minicomputers

askSam

askSam version 5.0 combines the capabilities of a personal information management system (PIMS), a relational database management system (DBMS), and a hypertext system. It uses a compact, powerful search engine that does not depend on rigid field specifications and record definitions, but instead searches the full text of a file. The program places no limits on the number of documents or file size from which information can be retrieved. Data can be entered in both fixed- and free-form fields, or imported from other word processing software. A scroll function lets the user browse documents for viewing or editing.

Flexible programming features provide the ability to access and interchange data between files. Records can be time- or date-stamped. Although there is no version of askSam written specifically for Microsoft Windows 3.0, it is possible to run the program under Windows because askSam can read files with a .PIC extension, as can Windows. The askSam Developer's Edition provides the features of askSam 5.0, plus an application generator to create custom front ends for the askSam database engine. An application can be locked to a run-time version of askSam to create a stand-alone product for distribution. However, askSam cannot perform embedded arguments in a search, and the program's complex design can cause inexperienced users to lose data or fail in a search.

This package runs on DOS-based IBM-personal computers (PCs) and compatibles with at least 348 kB of RAM and 1 MB of disk storage space. The retail price for askSam 5.0 is \$395. The askSam Developer's Edition costs \$695, including one run-time version. Additional runtime versions cost \$25 each. Its source language is C. Free telephone support is provided, and technical support is also available through an electronic bulletin board system (BBS). Upgrades are provided at a cost of \$125 from any version, and site licenses are available.

Ful/Text

Ful/Text is an information retrieval system that comes packaged as a software developer's toolkit. Ful/Text's index and retrieval tools are designed to be incorporated into custom programs written in C.

Ful/Text can base searches on individual words, exact phrases, proximity, and term variants. In addition, traditional Boolean and fuzzy Boolean searching is supported, as are search ranking and weighting. Searches based on free-form text, multilingual text, fielded data, text strings, and text integrated with images are all supported. Search aids such as index browse, thesaurus, stop words, word-variant rules, and cross reference are included to provide the ability to build sophisticated information retrieval applications.

Ful/Text employs a distributed client-server architecture that was designed to be adaptable to new network architectures as they come into existence. Ful/Text does not use the server merely as a remote disk, but places the entire search engine there.

The cost of version 5.0 ranges from \$5000 for an eight-user server license to \$50,000 for an unlimited server license. The system requires a minimum of 640 kB of RAM and 5 to 12 MB of disk storage. It has a graphical interface that supports Windows 3.0. Ful/Text is compatible with most major operating systems, including Unix, DEC VAX/VMS, ULTRIX, DOS, OS/2; HP 9000, Sun SPARCstation, IBM RS/6000/AIX, and Apple Macintosh. Site licenses are available.

TOPIC

TOPIC is a user-friendly document management package for the networked computing environment. It supports both local area networks (LANs) and wide area networks (WANs), and includes developer products for integration with SQL databases. TOPIC provides access to structured and unstructured data, internal or external information, published documents, and live newswire. It is based on concept retrieval technology, which allows end-users to create finely tuned queries that evaluate the content of a document, not just words. TOPIC presents to users a list of all the documents relevant to their search criteria, with the most pertinent documents presented first. TOPIC provides users with an easy query-by-example facility, simple word searches, powerful topic retrievals, and traditional Boolean retrievals.

The program uses dual-level indexes to increase retrieval speed. TOPIC's architecture allows document collections consisting of multiple formats to be searched while remaining in their native formats, saving conversion time and storage overhead. Information can be accessed regardless of document format, operating system, or network software.

TOPIC supports the most widely used graphical user interface platforms, including Microsoft Windows, Apple Macintosh, and Sun Microsystem's Sunview. It also operates across other major platforms, including DOS, OS/2, Unix, and VAX/VMS. Its price ranges from \$15,600 to \$150,000.

Folio Views

Folio Views, by Folio Corporation, is an information archiver that combines text retrieval and hypertext linking, and is well suited to networked environments. Individual files are prepared by separating each folio (segment of text) with a hard carriage return and Ctrl-E character. Folios are then imported into an existing information base ("infobase") or defined as a new infobase using a routine built into the program. Folios are indexed using a proprietary indexing system called "underhead" indexing. Folios can be saved into user-defined groups, called "views." For instance, an infobase that consists of the text of a software manual might include a named view of all sections that refer to importing files. Folios added to an existing infobase are indexed immediately, and existing folios need not be reindexed after additions are added.

Folio Views provides the ability to cross reference small sections of text in hypertext style. After the link tokens (cross references) are entered, users can jump to related text or explanatory notes within a view. The cross reference function can be used to set up indexes, tables of contents, and menus to guide users through an infobase.

Folio Views comes with a rudimentary word processor that can be loaded on command. However, this word processor does not have a search-and-replace feature, and it can import ASCII text files only.

Searches can be as complex as necessary, and may be based on logical Boolean operators, wild cards, or proximity matches. The results of each search appear in a window (to form a "view"). It can base a search on either broad or narrow specifications, giving the user a high level of control over this function.

Folio Views costs \$495. The system requires 512 kB of RAM, and program files occupy less than 400 kB on a hard drive. It is compatible with IBM PCs and compatibles using DOS 2.0 or later. Free telephone support is available. Technical support is also available and the company is currently setting up a user BBS.

ZyINDEX

ZyINDEX, an information retrieval package that uses indexers, is available either as a stand-alone program or networked, including a client-server version. The system is menu driven, with help screens at every level. It can index text prepared in more than 25 different word processing formats, so no special formatting or conversion processes are required. There is a Windows version available that provides concurrent displays of results from multiple searches—even on different indexes—and concurrent browsing of all documents and graphics files.

ZyINDEX is capable of complex searches based on word, phrase, proximity, wildcard, Boolean logic, nested expressions, defined fields, and concepts. It provides the ability to mark and save excerpts to a printer or file. Users can also print entire documents and generate reports with ZyINDEX. All documents can be viewed in their native formats.

Prices start at \$395 for a single-user version, and a five-workstation LAN package costs \$995. There is free (but not toll-free) technical support available. ZyINDEX requires a DOS-based IBM PC or compatible using DOS 2.0 or later, and at least 512 kB of RAM.

3 ENHANCEMENT ALTERNATIVES FOR DCIS

Considering the needs of DCIS and the technology available to meet these needs, enhancement of DCIS must be based on one of three alternatives: a mainframe-resident approach, a microcomputer/mainframe approach, or a microcomputer/minicomputer approach.

The Mainframe-Resident Approach

The mainframe-resident approach to enhancing DCIS is a continuation of the way DCIS has been developed to date. All code and data reside on a mainframe, and are accessed through a communications network. The program is maintained at a central location, and control of the information base by the system administrator is absolute: all users have access to exactly the same design criteria (i.e., the most up-to-date criteria).

This approach has several pitfalls. One serious problem is the cost of performing this type of work in an interactive network: connect charges and processing charges can add up quickly. This approach would tie the user to an expensive source of information, judging from current costs for using PAX. Furthermore, the new information retrieval functions desired would only increase those costs. Queries would consume more resource units and additional connect time. Based on the author's product research, several software companies appear to offer products capable of making the required enhancements (e.g., text retrieval). Some products offer graphic interfaces, and more are being developed. All of these products share a common drawback however: they are all highly dependent on the operating software of the host environment, and tend to be proprietary. This factor in itself would seriously limit the portability of any mainframe-resident enhancement of DCIS.

The Micro/Mainframe Approach

This approach would require DCIS to be a two-part program. One part—the main text and database—would reside on the mainframe. The executable portion of the program would reside on the microcomputer. The system would be centrally maintained and monitored for control. Actual operation of the program would be offline, on the microcomputer. The user would launch DCIS by logging onto the system through the mainframe. Through its user database and log, the mainframe program would verify that the user's microcomputer is loaded with the most current program files and design information. When the user files are verified, the user would log off the mainframe and run the executable program on the microcomputer.

The micro/mainframe approach would require a basic change in one original intent of DCIS: being accessible to the user without any major user adaptations. Until now the basic technological requirements for access to DCIS have been a microcomputer, a modem, and a communications program compatible with the PAX environment. Amount of memory, processor speed, type of video display, and other variables have been nonissues under the original system. For DCIS to execute on a microcomputer, the user would need a fast processor and lots of RAM. This would have to be considered a disadvantage of the micro/mainframe approach if it required many users to upgrade their computers simply to execute DCIS. On the other hand, because a large number of micro-based software applications are being standardized throughout the Army, any hardware upgrade required by this alternative would give the user more versatility to run other applications. It would also help overcome important technological barriers to implementing graphics retrieval capabilities in DCIS.

The Micro/Mini Approach

Using a combination of microcomputers and minicomputers to steer away from mainframe dependence would open the door to a larger and wider selection of hypertext, text retrieval, and graphics software. A system can be designed that uses the minicomputer for the host environment of DCIS. Using a communications network, the information residing on the minicomputer could be accessed by microcomputer-based workstations. CD-ROM technology would greatly enhance this approach. Like the mainframe, the minicomputer would still provide an environment for centrally maintaining and controlling the program. It would still be possible to ensure that the DCIS user has access only to the most current information.

A micro/mini approach would offer maximum portability. It would also provide great flexibility in setting up the network and procedures for data access. Apparent drawbacks include (1) limits on the number of simultaneous users, and (2) maintenance requirements. Reliability of minicomputer systems is very good, but backup systems and scheduled downtime for these units may require more effort and raise maintenance costs. If these higher maintenance costs were passed on to the user, a micro/mini system could possibly be as expensive as a mainframe-based program. Also, the response time for such a system would lag behind the mainframe, based on processing speeds.

The mainframe DCIS currently operating under the PAX environment has worldwide telecommunications capability. In order for the micro/mini based system to operate successfully, the same kind of worldwide telecommunications capabilities would have to be established.

The Viable Alternatives

Based on the preceding discussion, it appears that two alternatives could satisfy future DCIS demands at a reasonable development and implementation cost.

The Micro/Mainframe Alternative

The micro/mainframe alternative would transfer DCIS operation from a mainframe-hosted system to a microcomputer application. DCIS would be a two-part system. The main text and database would reside on the mainframe, as would the program updates and communications link to the program manager. The system would continue to be centrally maintained and monitored to ensure integrity of the program and the information base. The executable portion of the DCIS program would reside on the user's microcomputer. Actual operation of the program would be offline, avoiding substantial mainframe processing charges. An archive program would probably be required to conserve disk space by compressing DCIS files, databases, and related software when the system is not in use.

System operation would require registered DCIS users to log onto the mainframe to verify that DCIS program files on the microcomputer are current. The mainframe-resident program would compare the user's program and data files with the most current program and data files loaded onto the mainframe. If the user's files are not current, the mainframe program would transfer all data necessary to completely update them. As soon as the mainframe-resident program has updated DCIS or verified that it is current, the user can log off the host system. At that point the user would be assured of accessing only the most current AEI files.

The Micro/Mini Alternative

This approach would transfer DCIS operation from a mainframe-hosted system to a minicomputer application. Under this alternative DCIS would remain a remote-access system, similar to the mainframe program currently in use. The main text and database would reside on the minicomputer, physically located on a CD-ROM. The CD-ROM is an excellent medium for storing vast amounts of data very compactly, an important advantage when dealing with huge amounts of text and picture data. The actual DCIS program software would also reside on the minicomputer, and could be structured to keep the same menus and options available in the current mainframe version of DCIS. AEI updates would be provided through a separate hard disk, which the program would review and revise as necessary. The communications link between the program and the user would be over a dial-in network. The system would be centrally maintained and monitored to assure system integrity, as is the current system. The user would operate the program through the communications link.

The micro/mini alternative would require the registered DCIS user to log onto the remote minicomputer. This would be done through a communications package compatible with the host minicomputer's communications software. The minicomputer program would perform an update task that is invisible to the user. In its standard operation the system would receive commands from the user and query the CD-ROM for the information. The updating would be accomplished through command lines in the DCIS code that check the first disk against a second one containing AEI revisions. The system would use an artificial intelligence application to note the revised information for reference during user queries. The program would automatically provide the user with the correct data, obtained either from the original CD-ROM or the revision disk. This updating procedure would be invisible to the user.

Software Supporting the Micro/Mainframe Approach

The micro/mainframe alternative could be implemented with available technology, exploiting recent software developments that further enhance the appeal of this alternative.

Hypermedia Technology

The evolution of commercial hypermedia technology has been significant in the past 2 years. Microsoft Windows, a graphical interface overlay for the DOS environment, offers basic hypermedia capabilities, such as allowing the user to switch tasks without exiting a program, or copy information from one application into another. Although it is not the most sophisticated hypermedia environment available, it will perform the functions necessary to make the micro/mainframe alternative work. Drawings developed under computer-aided design (CAD) software can be saved as pictures (.PIC files), so a revised AEI drawing can be viewed and incorporated with the text of the AEI, and need not be stored separately under a CAD program. Since the construction industry is standardizing on software programs that can interchange .PIC files, the micro/mainframe alternative would make DCIS text and drawings more accessible than ever.

PC Dugout

Another software development supporting this alternative is a program called PC Dugout, an application that automatically manages distribution and updating of software from the PAX mainframe environment to microcomputers.

PC Dugout was developed by USACERL as a transparent software application for the distribution and control of applications on the PAX system. PC Dugout is designed to aid in the productive use of personal computers connected to PAX. The program enables previously centralized processing tasks to be distributed to personal computers, resulting in lower operating costs and improved user interfaces. PC dugout automatically distributes and maintains personal computer applications developed to support the Military Construction, Army program (Japel et al, 1991).

PC Dugout provides key capabilities in support of the micro/mainframe alternative. The program "addresses the challenge of providing an efficient, reliable method for distributing and updating PC applications while exercising an effective level of system management for a group of users that constantly changes and possesses varying degrees of computer proficiency." (Japel et al 1991).

Software Supporting the Micro/Mini Approach

Technology also currently exists to make the micro/mini alternative feasible. CD-ROM technology is gaining wider popularity among computer users due to technical enhancements and falling prices. One source for design criteria on CD-ROM is the Construction Criteria Base (CCB), marketed by the National Institute of Building Sciences (NIBS). CCB is the database of design and construction criteria used by the Naval Facilities Engineering Command (NAVFAC).

Software Supporting Both Approaches

Network Technology

Network technology is now very mature and can readily be adapted to enhance DCIS. LAN technology has advanced to the point where voice, video, and data transmission can be combined. These systems can work across a single wire, a shielded twisted pair of wires, fiber-optic cable through the use of an integrated adapter, the commercial telephone system, a multistation access unit, or a network gateway. Hardware add-on components required for implementing a multimedia network include integrated node adapter cards, digital feature phones, node-coupling multistation access units, and a network gateway for communicating over wide area networks.

DOS Upgrade

There have recently been substantial advances in DOS, the operating system used in IBM PCs and compatible microcomputers. Both Microsoft Corp. and Digital Research, Inc., have developed versions of DOS—version 5.0—that include graphical shells and task-switcher functions, which allow a user to move from one program to another without closing down the first (as does Windows). These operating system enhancements will be valuable in any upgrade of DCIS that incorporates DOS-driven systems.

4 SUMMARY AND RECOMMENDATIONS

The integration of hypermedia capabilities into DCIS will require a major restructuring of the program's format and, therefore, rewriting of the code. Integration of hypertext and graphics functions can be accomplished through any of the three alternatives discussed here: implementation on mainframe only, on microcomputer and mainframe, or on microcomputer and minicomputer. Cost will have a fundamental impact on decisions about the specific configuration of any alternative. The main focus of this study was on the state of relevant technologies, however, not the specific cost implications of all possible alternatives.

Based primarily on technological considerations, the mainframe-resident approach appears to be the least viable of the three alternatives. This approach simply does not offer as many choices or as much flexibility for graphics integration as the other two. Because of this limitation, it is recommended that hypertext and graphics capabilities for DCIS not be pursued as a mainframe-resident system.

The micro/mainframe and micro/mini alternatives both offer the flexibility required for integrating the desired enhancements. On the surface, converting DCIS to a micro/mainframe system would appear to place a significant new cost burden on the user. For a system including all current DCIS features and desired enhancements to execute on a microcomputer, many users would have to upgrade processors, RAM, etc. Therefore, of these two alternatives, the micro/mini alternative appears to be the more promising approach. Such a system would execute in the minicomputer environment and take advantage of the data storage capabilities of CD-ROM technology. Microcomputers would access DCIS over a telecommunications system. Since DCIS would reside on the minicomputer, the microcomputer would not need to be upgraded to execute the program. Based on the authors' survey of software technology, this approach also offers the developer the largest selection of hypertext, text retrieval, and graphics packages. Using a minicomputer as the host environment would continue to allow centralized maintenance of DCIS. Considering the wide variety of software available, this system would provide for maximum portability of DCIS, and would offer virtually unlimited approaches to setting up the network and access to data.

Therefore, it is recommended that enhancement of DCIS should be implemented as a microcomputer/minicomputer system. Considering the experience of NIBS with the distribution and updating of construction and design criteria on CD-ROM technology, it is recommended that the Corps explore an appropriate partnership with that organization to jointly develop the desired enhancements for DCIS.

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LIST OF ABBREVIATIONS AND ACRONYMS

BBS	bulletin board system
CAD	computer-aided design
CCB	Construction Criteria Base
CD - ROM	compact disk - read only memory
DBMS	database management system
DCIS	Design Criteria Information System
DOS	disk operating system
HQUSACE	Headquarters, U.S. Army Corps of Engineers
LAN	local area network
NAVFAC	Naval Facilities Engineering Command
NIBS	National Institute of Building Sciences
OCR	optical character recognition
PAX	Programming, Administration, and Execution
PIMS	personal information management system
RAM	random access memory
SQL	structured query language
USACE	U.S. Army Corps of Engineers
USACERL	U.S. Army Construction Engineering Research Laboratory
VM/CMS	Virtual Machine-Conversational Monitor System
WAN	wide area network

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